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TERRESTRIAL MAGNETISM.

[Communicated.]

NO. 1.—ON THE SECULAR VARIATION OF THE MAGNETIC NEEDLE AT LONDON SINCE THE YEAR 1580.

From an examination of the movement of the compass-needle producing declination at London, I find that the various vicissitudes the needle has undergone during the last 300 years, can be explained by supposing that its movements have been governed chiefly by those of a *strong* magnetic pole revolving round the pole of the earth in about 500 years. I may here state that, in order satisfactorily to explain all magnetic phenomena, four magnetic poles appear to be necessary.

Let M N (fig. 1) be a compass-needle at London, directed to the true north, O. In the year 1660 that was its direction; in 1580 it was 11° 17′ E.; in 1816 it was 24° 17′ W.; and in 1877 it was 18° 57′ W.

Along the arc W A E, mark off A E = 11° 17′ to the east of A, and A W = 24° 17′ to the west of A, and let A be at the point which marks true north direction.

Let lines M E, M A, M W, be drawn and produced to meet in D O and C, a concentric arc drawn through the north pole, O.

Describe a circle C D D through the points C and D, M D and M C being tangents.

From E to W mark off all the different positions of the needle in its westward movement from 1580 to 1816, and let the lines be continued to meet the circle along D N C.*

Along the arc P R mark off the positions of the needle moving to the east since 1816, and let the lines combine to meet the circle in C H.

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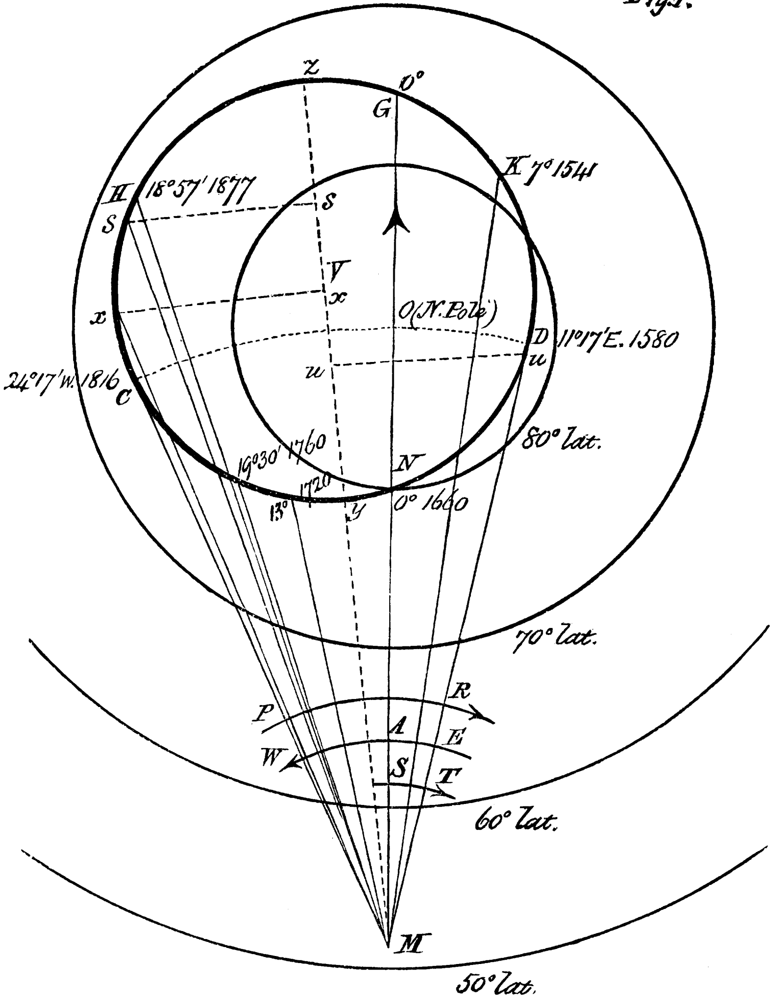
* Only the chief positions are given in the figure.

Fig. 1.


z
0°
G
K 7° 1541
H 18°57' 1877
S
s
V
x
x
O (N. Pole)
D 11°17'E. 1580
u
w
24°17'W. 1816
C
80° Lat.
19°30' 1760
1720
13°
y
N
0° 1660
70° Lat.
P
R
A
E
W
S
T
60° Lat.
M
50° Lat.

Along S T mark off the position of the needle moving east before 1580, and let the line be produced to meet the circle in K.

Now, it has been observed that the needle moved very slowly about D and C, the points of eastern and western declination, and not only so, but the movement gradually decreased as it approached and gradually increased as the needle receded from the points D and C. Such would be its movement, if the needle be supposed to point constantly to something moving along the circle D N C H.

It follows that when that which directs the needle came to the point N on the circumference, the needle would point due north, and there would be a line of no declination passing through London. This actually happened in the year 1660.

It follows that the greatest movement of the needle would be when it pointed to V, the centre of the circle, and also before and after. Now during the thirty years from 1670 to 1700 (the needle pointing to V about the year 1685) the average rate of movement was 15′ a year—a rate considerably greater than that of any other period since observations have been made; indeed, it was nearly double the average rate since 1580, which is about 8′.

It follows that places to the east of London, as Königsberg and Copenhagen, would have the line of no declination, which passed through London in 1660, pass there about 1600 and 1620; and such was the case.

It follows that when the magnetic pole was at G, a line of no declination passed through London, traveling west, about the end of the 15th century. There is, of course, no record of such for London, but we do know that in 1402 Columbus found it east of the Azores. What has become of this line of no declination? I shall show when I treat fully of such lines.

It follows from the figure, that the needle at St. Petersburg would be nearly stationary from 1722 to 1774, as the magnetic pole from that place would appear to be moving in almost a straight line. Why there is such a small amount of westerly declination at St. Petersburg I shall show when I treat of the declination at that place.

It follows from the figure, that the needle at New York must have moved very slowly during the time between 1686 and 1723, and at a much more rapid rate between 1789 and the present time. I find that in the former period it moved at the rate of only 2¼′ a year, in the latter period at double that rate.

It follows, if this theory is correct, that the magnetic pole must have been not far from 90′ west longitude when the needle at London had its greatest westerly declination in 1816. Now, Sir James Ross, in 1830, found the magnetic pole in 96° 43′ west longitude. The needle in London in 1830 pointed to about 96° west longitude; the pole was discovered to be in the same longitude. Supposing the pole to have traveled at the same rate since, it would be now about 115′ west longitude. In confirmation of this, I may say that a needle at London pointing to 114° 45′ west longitude would have 18° 50′ westerly declination. This is the declination of the needle at London at the present time.

It may then be reasonably concluded that the magnetic pole will now be found in latitude 72° 15′ N., and longitude 114° 45′ W., or in the middle of Prince Albert Land.

It will be seen from the figure that while the needle passes from C to G it is retracing values it had when it moved from N to C. If, therefore, we find the positions of the needle the same number of years before and after 1816, they ought not to differ much.

Take 38 years before and after 1816 :

816	24° 17′	1816	24° 17′
1778	22° 11′	1854	22° 00′
38	2° 6′	38	2° 17′

These differences, 2° 6′ and 2° 17′, agree very well.

Or, suppose we take a much longer period, say 60 years :

1816	24° 17′	1816	24° 17′
1756	18° 50′	1876	19° 8′
60	5° 27′	60	5° 9′

These differences, 5° 27′ and 5° 9′, are very close for such a long period as 120 years—60 before and 60 after 1816.

From an examination of the movement of the needle along N C, it would appear that about 1892 the western declination will be 16° 10′ W., that it will decrease slowly till about 1905, will increase slightly for the next 20 years, and after 1925 will begin to move along rapidly, reaching the point G and the declination becoming

0° about 1990. Continuing its course eastward, about the year 2072 it will arrive at the point D, where it was in 1580, having made a complete double oscillation and the pole a complete revolution in 492 years.

We know that in the year 1541 the needle had about 7° east longitude and was at the point K. Now, from K round through N to H is about two-thirds of a circle. The magnetic pole has therefore to pass over the distance H G K (about one-third of the circumference) before completing a revolution.

The space K N H has been traversed in 336 years; at the same rate H G K will be traversed in about 168 years. Therefore the time of performing one revolution will be about 504 years, which confirms what has been already shown, that the magnetic pole makes one revolution in about 500 years.

No. 2.—On the Dip of the Magnetic Needle at London since 1576.

Having shown that the declination-needle in its secular movement, as observed for the last 300 years, is always directed to a magnetic pole which appears to revolve round the north pole of the earth in about 500 years, I purpose strengthening this conclusion by adducing the evidence afforded by the dip. This evidence will besides show, in the clearest manner possible, that the north end of the needle is, contrary to the belief and teaching of the last 300 years, a north pole, not a south pole.

Let a plane cutting the earth be supposed to pass through V (fig. 1), the centre of the magnetic polar curve, and through M, or London, where the needle is supposed to be; and on *z* V M project the positions *u*, *x* and *s*, of the magnetic pole, in the years 1576, 1833, and 1866, as indicated by the position of the needle.

Let the section resulting from this plane cutting the earth be represented by *z* M (fig. 2). Let *e* be the centre of the earth and *e r* a radius at right angles to the semi-axis, N *e*. The positions *u*, *y*, *x*, *s*, *z* (fig. 1) of the needle will be represented in figure 2 by the same letters. M is the position of London, and *h o* is a dipping-needle there in a horizontal position.

Now, if the needle dips *to* the magnetic pole (even supposing it to be in the same position in which Sir James Ross found it in the

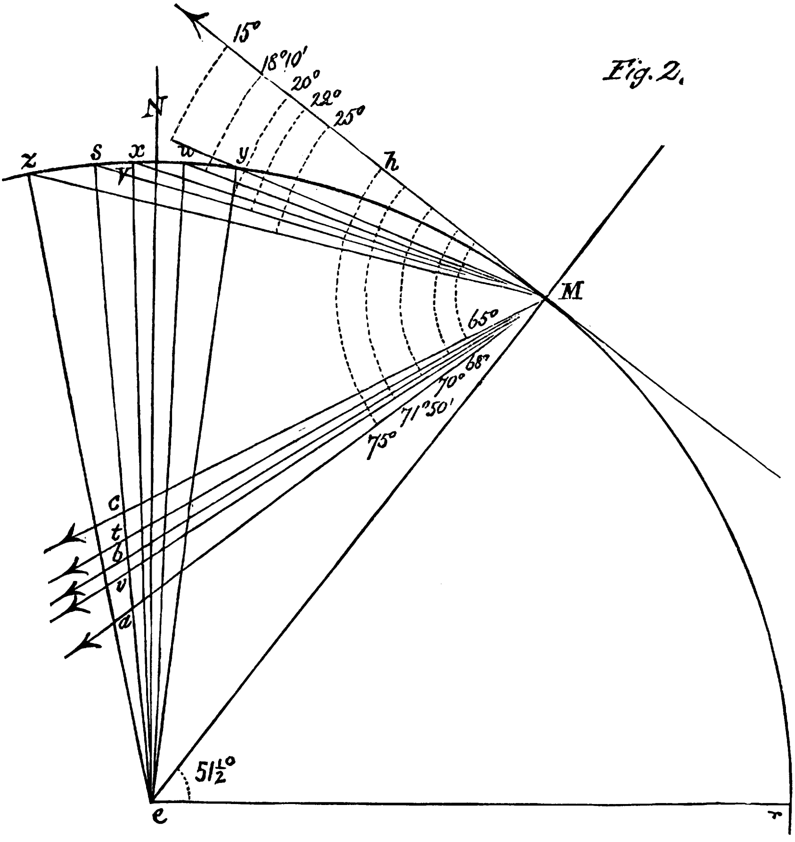


Fig. 2.

year 1833), it ought to dip to the position *x* (figs. 1 and 2); but even then the angle of dip would be only about 20°, whereas the dip at that time was about 70°. Now this angle, 20°, is the complement of the dip, and this is an important clue to the solution of the matter.

Suppose now the needle to dip to the several positions which I have shown in fig. 1 the pole would have, if it were in revolution. With the pole near the position Y, where I have shown it was at the beginning of the 18th century, the dip would be (fig. 2) 15°; but this is the complement of the real dip at that time—75″.

With the pole at the position U, where it was about 1566, the dip would be about 18° 10′; but this is the complement of 71° 50′, the actual dip at that time, as found by Norman.

With the pole at the position X, where it was about 1833, the dip would be 20°; but this is the complement of 70°, the true dip at that time.

With the pole at the position S, where it was in 1866, the dip is 22°; but this is the complement of 68°, the real dip at that time.

And to look into the future, with the pole at Z, its farthest position from London, where it will be about the middle of the 20th century, the dip is 25°, which is the complement of 65°. This, I hold, will be the least angle of dip, from which time the dip will begin to increase, until the pole has reached Y, when it will be at a maximum. Thus we have the range of the dip at London 10°, from 75° a maximum to 65° a minimum. Now we know that in 1680 the dip was 72° 30′, and approaching a maximum, which it reached early in the 18th century. All this is fully borne out by supposing that the magnetic pole revolves round the pole of the earth in about 500 years, as was proved by the declination.

But to return to fig. 2. Ma, Mv, Mb, Mt represent the actual directions of the dipping-needle at London about 1720, 1576, 1833, 1866. The needle being a dipping-needle, and the universal belief being that its north end is attracted by the north magnetic pole of the earth, it ought certainly to be drawn to point to the north end of the earth; but so far from this being the case, it seems to be repelled from it, and repelled it is, I hold.

There comes, then, this very natural inquiry: Have we, for hundreds of years, been maintaining that the end of the needle which is directed to the north is the south pole of the needle, and upholding that which is the very opposite of fact? Every unprejudiced mind will admit that it must indeed be so. Indeed, the facts, when properly understood, are found to be in full accord with the great magnetic truth that like poles repel, unlike attract.

If the dipping-needle be taken to the arctic regions, it will be found in one locality to point to the ground, to be nearly perpendicular. It should be borne in mind that Sir James Ross never found it truly perpendicular, which itself would tend to show that the magnetic power was not *in* the earth. If the dipping-needle is repelled from the pole at London, much more will it be repelled in Boothia, and it is repelled as much as it possibly can be. The north end of the needle is repelled from the pole which is in the atmosphere, and the south end of the needle is as much attracted by the same pole; and this is as it should be—the north pole of one magnet (the terrestrial) attracting the south *pole* of another.

If the north end of the needle is a south pole, as it points to the ground, this should be because it is attracted. If it is attracted, it is attracted by something in the crust or at the centre of the globe. If there is something in the crust which attracts the needle in Boothia, it ought to attract the needle in London; but the needle at London is attracted neither to the crust at Boothia nor to the centre. The magnetic pole, then, appears to be in the atmosphere.

The fact that the declination-needle points constantly to the magnetic pole does certainly seem to indicate that it is attracted; but it is impossible to believe this, when the same needle and the same end, dipping, is manifestly repelled. The true explanation of the *apparent* attraction is, I believe, this: the needle places itself in the magnetic meridian as in a position of equilibrium, which the moving magnetic pole is constantly disturbing.

Even the north end of the declination-needle manifests a certain amount of the repulsion produced by the north magnetic pole of the earth, which is shown by the north end becoming apparently heavier directly it is magnetized. It is impossible to believe that the mere touching a needle with a magnet can give it weight. We are, then, driven to the conclusion that the north end must be attracted or repelled. Norman arranged the needle so that it should move freely in a vertical direction, and discovered that this *apparent* heaviness was really a dipping. I have shown that the dip is produced by repulsion.

As the declination-needle was known long before the dipping-needle, such a universal belief got abroad that the north end of the needle was attracted by the north magnetic pole because it pointed to it, and that therefore that end of the needle must be a south or austral pole; that, when the dipping-needle was invented, it never occurred to the acutest minds that the same end in the dipping-needle was proclaiming in the most distinct manner that it was not attracted, but repelled—that it was not an austral pole, but a boreal one.

In conclusion, I would remark that it is admitted that the phenomena of terrestrial magnetism are most satisfactorily explained by four poles—two in the northern and two in the southern hemispheres, as maintained by Halley and Hausteen. I hope to show, hereafter, that the two magnets, as it were, having these poles, are not in the earth, but in the atmosphere; that instead of two rigid magnets in the earth, whose extremities come to the surface near the poles, there are two broad atmospheric magnetic belts extending from the neighborhood of the north pole to the equator, and two similar belts coming up from the south pole to meet them—the austral magnetism of the northern belts uniting with the boreal magnetism of the southern belts along the magnetic equator; the magnetic poles in each case being the free extremities of the magnetic bands. These bands revolve, at slow and unequal rates, round the poles of the earth, producing the secular variation.

It is of the first importance, then, that it should be clearly settled whether the magnetic pole, which Ross fifty years ago discovered in Boothia, is still there or has moved to lat. 72° long. 115° W.

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